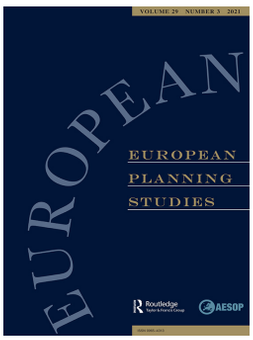

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New directions for RIS studies and policies in the face of grand societal challenges

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ABSTRACT

The regional innovation system (RIS) approach has become a widely used framework for examining the dynamics of innovation across space and for crafting policies to promote the innovation capacity of regions. The dominant focus has been on technological and business innovation enhancing competitiveness and economic growth. In light of persistent environmental and social challenges such as climate change, aging and growing inequalities, this understanding appears to be too narrow. We argue that the RIS approach requires a critical reassessment for informing the next generation of regional innovation policies. We explore how RIS scholarship and policies could benefit from an alternative understanding of the innovation process. Inspired by recent work on mission-oriented and transformative innovation policies, we develop the notion of 'challenge-oriented RISs' (CoRISs). In contrast to conventional understandings of RISs, this approach embraces a more critical view of innovation, captures the directionality of change, opens up to new innovation actors at different territorial scales and pays more attention to the application side and upscaling of innovation within the region and beyond. Acknowledging that regions vary in their capacity for transformative change and challenge-oriented innovation, the article outlines new directions for place-based innovation policies.

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1. Introduction

Over the past decades, the regional innovation system (RIS) concept has become a powerful framework for explicating why regions vary markedly in their innovation performance and why such spatially variegated patterns tend to persist over time (Asheim, Isaksen, and Trippl 2019). It has also proven to be a major source of inspiration for regional policy-makers. Questioning 'one size fits all' policy approaches (Tödtling and Trippl 2005), RIS scholarship has provided a sound foundation for the design and

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implementation of more place-based innovation policies. The recent uptake of smart specialization (Foray 2018) in Europe and elsewhere is a prime example of this.

Following Schumpeter (1911), the prevalent interest of conceptual and empirical RIS studies as well as of regional innovation policies has thus far been on technological, organizational and marketing innovations and their effects on competitiveness and economic growth. In the face of persistent environmental and social challenges such as climate change, environmental degradation, growing inequalities and poverty, this focus of RIS scholarship and policies appears to be too narrow (see, for instance, Tödtling and Trippl 2018; Coenen and Morgan 2020). We contend that the RIS notion requires critical rethinking to provide a useful basis for enhancing the effectiveness of regional innovation policies in solving societal problems. This article draws on a growing body of work on new concepts such as mission-oriented (Mazzucato 2018), challenge-oriented (Raven and Walrave 2020) and transformative innovation policies (Schot and Steinmueller 2018; Diercks, Larsen, and Steward 2019) to address the question how the RIS approach and regional innovation policies could be reoriented to today's grand societal challenges.

The remainder of this article is organized as follows. Section 2 provides a review of recent concepts of innovation policy and transformative change. Section 3 outlines how RIS scholarship could benefit from emerging debates on alternative understandings of innovation and innovation policy. Section 4 introduces the notion of challenge-oriented RISs (CoRISs). In Section 5, we take the Austrian region of Vorarlberg as an example, illustrating core features of the region's evolving CoRIS in relation to a specific challenge, i.e. climate change and mobility. Section 6 concludes and identifies some key questions for future research.

2. Recent concepts of innovation policy and transformative change

In view of current societal challenges, the RIS approach requires fundamental rethinking and modification. Fruitful ideas and key elements in this regard can be found in the mission-oriented approach to innovation policy and transformative innovation policies, among others. Although these literatures usually neglect geographical context, they address important issues and offer ideas that are helpful for revising the RIS approach. They argue for a broader understanding of innovation that includes social and institutional innovations besides those in technological and business fields (Avelino et al. 2019; Moulaert and MacCallum 2019). What is more, they suggest that rather than solely aiming at economic growth, the focus of innovation policy needs to shift towards tackling grand societal challenges and transformative change (Coenen, Hansen, and Rekers 2015; Raven and Walrave 2020). Uyarra, Ribeiro, and Cale-Clough (2019) note that this would reflect a 'normative turn' in innovation policy. However, it is important to note that traditional innovation policies also have implicit normative goals and orientations (e.g. creation of 'good' jobs, income and wealth by enhancing the innovation capacity of firms and industries located in the region).

Challenge orientation and directionality of innovation have been stressed by the mission-oriented approach to innovation policy (Mazzucato 2018; Mazzucato, Kattel, and Ryan-Collins 2020), among others. It aims at major scientific, technological or societal breakthroughs, like finding new sources of energy (e.g. renewable energy,

atomic fusion reactors), exploring new ways of mobility (e.g. self-driving vehicles) or fighting certain diseases and their sources (e.g. cancer or COVID-19). This approach emphasizes the directionality of the innovation process by identifying ex-ante problems to be targeted by innovation policy. For Hekkert et al. (2020), a societal challenge-based mission 'requires transformative systems change directed towards overcoming a wicked societal problem' (76). They introduce the notion of mission-oriented innovation systems (MIS) that are defined as networks of agents and sets of institutions contributing to the development and diffusion of innovative solutions to define, pursue and complete a societal mission (Hekkert et al. 2020).

Raven and Walrave (2020) argue that challenge-oriented innovation policies could be based on the concepts of the technological innovation system (TIS) and the multi-level perspective (MLP). TIS scholars do not only emphasize knowledge generation and exchange but pay attention to a wider set of system functions or processes (such as entrepreneurial experimentation, market formation, resource mobilization, legitimacy) that shape the generation of innovation and their implementation and exploitation (Bergek et al. 2008). A key argument of the MLP is that confronting grand societal challenges requires more than technological and business innovation, namely a fundamental system change (Geels 2002, 2004; Markard, Raven, and Truffer 2012). MLP studies analyse transformative shifts in systems of production and consumption that go along with disruptive technological innovation and changes in markets, infrastructure, user practices, policies and governance.

Also, the burgeoning literature on transformative innovation policy puts socio-technical system change into focus (Schot and Steinmueller 2018). This contrasts with traditional innovation policies that pay attention to correcting structural innovation system failures such as infrastructural failures, capabilities failures, network failures and institutional failures (Lundvall and Borrás 2005; Weber and Rohracher 2012; Fagerberg, Martin, and Andersen 2013). Systems fulfilling basic needs (such as energy, mobility, food, water) are seen to require fundamental shifts in order to become truly sustainable. This implicates social, behavioural and technological changes in an interrelated and often radical way. It includes changing skills, infrastructures, industry structures, products, regulations, user preferences and cultural patterns. Since these elements tend to be aligned and may reinforce each other, system innovations and transitions are cumbersome and long-term processes that involve multiple actors, including civil society and users (Schot and Steinmueller 2018, 1562). Weber and Rohracher (2012) propose that policies for transformative change should address four types of failure, that is, directionality failures, demand articulation failures, policy coordination failures and reflexivity failures (see also Raven and Walrave 2020). Actions have to be taken by a broad and diverse set of actors both to formulate and to address those challenges. Since resistance from incumbent networks benefitting from the current situation can be very strong, the policy mix needs to address also the de-stabilization of existing locked-in socio-technical systems and networks that may include industries, users, civil society and (parts of) governments (Kivimaa and Kern 2016).

Finally, there is a growing awareness that 'innovations can also have negative outcomes and may even exacerbate societal challenges, rather than contribute to tackling them' (Diercks, Larsen, and Steward 2019, 882). The literature on responsible research and innovation (RRI) moves societally desirable innovation outcomes centre stage

(Owen, Macnaghten, and Stilgoe 2012; Stilgoe, Owen, and Macnaghten 2013; Von Schomberg 2013). While traditional innovation policy models highlight the need of coping with negative externalities of new technologies, RRI intends to orient the innovation process better towards societal goals. Like the mission-oriented approach, RRI calls for greater attention to directionality and the purpose of innovation. Coenen and Morgan (2020) point to a severe limitation of this approach, arguing that its main focus is on the design and framing of research and innovation processes and programmes, while little is said about their implementation. It is not very explicit about the capabilities and institutions needed to make it happen.

Arguably, the approaches discussed above are insensitive to geographical context. Yet, they provide fruitful starting points for revisiting RIS scholarship and regional innovation policies that are taken up in Section 3. Our literature review points to some major common issues in this regard, including a broader understanding of innovation, consideration of societal challenges and goals (directionality), the inclusion of new innovation agents, and a new and enriched role of policy.

3. RIS scholarship and policies: beyond the state of the art

How can the RIS approach benefit from engaging with current debates on modern innovation policies as outlined above? Before distilling some key insights in this regard, we take stock of the main arguments of the RIS concept. Over the past three decades, various territorial innovation models (for an overview, see Moulaert and Sekia 2003) have sought to explicate the uneven distribution of innovation in space. The RIS concept can be seen as a synthesis of research on the topic (Cooke 1992; Asheim, Isaksen, and Trippl 2019). It casts light on how interactive learning between multiple actors (primarily firms, research and educational bodies, intermediaries, policy-makers) underpins regional innovation activities in the firm sector. Key actors and the networks that knit them together are viewed as being embedded in and influenced by the institutional set-up in regions. The innovation capacity of regions is thus understood as the outcome of systemic interdependencies between actors, networks and institutions. RISs are also seen as open systems in which actors access knowledge and other resources needed for innovation by engaging in extra-regional networks. Further, RIS dynamics are influenced by national and international policies and institutional framework conditions. In other words, the performance of a RIS does not only depend on what happens inside the region but also on processes that take place outside its territorial boundaries.

A large body of work has demonstrated that regions show varying endowments of key elements of RISs (see, for instance, Isaksen and Trippl 2017) and that regions and their innovation systems differ markedly in the ways in which they are inserted into global production, innovation and market linkages (Binz and Truffer 2017; Trippl, Grillitsch, and Isaksen 2018). The RIS concept has been used both as an analytical tool to analyse the innovation strengths and weaknesses of regions, and – partly based on this – as a tool for developing and assessing spatially targeted systemic innovation policies. This has helped to overcome one-size-fits-all policies and stimulated academic debates about the nature of 'region-specific', place-based policy approaches and practices (Tödtling and Trippl 2005; Morgan 2017).

The conventional RIS approach has many merits, but it is also fair to argue that RIS scholarship has thus far not engaged sufficiently with recent debates on innovation

policies outlined in Section 2. In particular, the following aspects need consideration in revising and extending the RIS concept.

First, RIS scholarship has thus far not sufficiently taken account of the broader understanding of innovation that has emerged over the past few years (Tödtling and Trippl 2018; Coenen and Morgan 2020). The traditional RIS approach centres too much attention on technological and business innovation, leaving other innovation types (such as social innovation, user innovation, institutional innovation) emerging in economic and other realms (public sector, civil society, regional and urban communities) aside (Warnke et al. 2016; Moulaert and MacCallum 2019).

Second, there are calls to address societal challenges such as climate change, social inequalities and the aging society, also at a regional scale. This implies to lead the innovation process in certain directions in order to solve such societal problems (Foray 2018; Tödtling and Trippl 2018). The purpose of innovation is not limited to fostering economic competitiveness, as the traditional RIS approach suggests. Instead, innovation is rather seen as a response to societal needs, informed by ideological norms and values (Bryden and Gezelius 2017; Raven and Walrave 2020; Coenen and Morgan 2020).

Third, it is argued that the innovation and policy process should be more inclusive, participatory and open towards various kinds of users and stakeholders such as affected interest groups and civil society organizations, also at the regional scale. In other words, opening up the innovation process to a broad variety of innovative agents besides firms and their support organizations gains in importance.

Fourth, RIS studies have long focused on the supply side of innovation, explaining where innovation is generated in technological, sectoral and geographical spaces. Less attention has been paid to the application side, that is, how regions use and apply innovations generated and produced in the region or elsewhere to solve concrete problems on the ground (Tödtling, Trippl, and Frangenheim 2020). The determinants of regional application capacities (e.g. the capacity to anchor or embed solutions) often remain blind spots. Regional innovation policies thus need to overcome its strong focus on the supply side and should aim at the broader set of generation, adoption, application and upscaling of innovation. This includes also a better coordination with other policy fields, such as environmental or health policies, to achieve the intended outcomes (Diercks, Larsen, and Steward 2019).

Fifth, the conventional RIS literature is often dealing only with the design of 'smart' strategies and the proposal of a proper set of tools. They do not take account of the complexities and problems of implementing these policy concepts (Flanagan and Uyarra 2016). This has severely limited their overall effectiveness in achieving policy goals and their ability to transform industrial structures and innovation systems.

Sixth, many RIS studies depart from the assumption that innovation is always positive, ignoring that it may also have a dark side, leading to unfavourable outcomes (Schot and Steinmueller 2018; Coad et al. 2021). Arguably, innovation may not only lead to creative destruction (Schumpeter 1911) but also to destructive creation (Soete 2013). In other words, innovation may create more problems than it solves. RIS studies and policies should take this aspect of innovation effects better into account by focusing on measures that have a high potential to tackle grand societal challenges at the regional scale. This includes regulations e.g. in the transport, housing or production sectors that reduce or prevent negative societal outcomes of particular innovations.

Finally, there are calls for a new role of the state. The role of policy should clearly go beyond classical STI and innovation systems policies since there is the need to address societal challenges in a broader way. Due to the widening of the goals, actors and affected groups, it seems important that policy actors take account of a more complex innovation landscape. Besides the traditional role of funding and infrastructure provision, this includes a stronger role of organizing and coordinating a more open innovation process, e.g. by setting up policy platforms, coordination of cross-cutting themes and working groups (representing technological, business, ecological and social topics). Such a policy approach needs to include a wide variety of actors and interest groups. It also requires mechanisms to deal with conflicting interests within such complex actor constellations.

4. Towards challenge-oriented regional innovation systems and policies

As outlined in the previous section, today's societal challenges call for a reorientation of RIS studies and regional innovation policies. In this section, we seek to initiate a discussion of how the RIS approach could be modified. To this end, we propose the notion of the challenge-oriented RIS (CoRIS). Grand societal challenges are often of global nature, but that they may have specific regional manifestations. A CoRIS thus operates at a regional scale, but it is interrelated with national, European and global scales in terms of flows of knowledge and resources, regulations and policies.

In contrast to traditional accounts of RISs, the CoRIS approach embraces a broader and more critical understanding of innovation, captures the directionality of change, opens up to new innovation actors and novel coordination mechanisms between various stakeholders and territorial scales, and pays more attention to the application side and upscaling of innovation within the region and beyond (Table 1). In short, CoRISs could be understood as (those parts of) RISs that feature a challenge orientation. As explicated further below, regions often face various challenges at the same time. CoRISs are RISs that show the capacity to (i) mobilize existing actors, resources (assets), networks and

Table 1. Conventional and challenge-oriented RISs: key differences.

	Conventional RIS approach	Challenge-oriented RIS approach
Type of innovation	Innovation in the regional corporate sector: technological, organizational, marketing innovation	Innovation in the regional corporate sector and in other realms (public sector, civil society, regional and urban communities: technological, user, social, institutional innovations)
Purpose of innovation	Economic growth and competitiveness of the regional economy	Grand societal challenges and problems faced by the region
Effects of innovation	Focus on positive effects (strong pro-innovation bias)	Focus on multi-dimensional effects of innovation: bright and dark sides
Actors, networks, institutions	Firms, universities, state, intermediaries knit together in stable (local and non-local) networks and embedded in a static multi-scalar institutional landscape	Conventional RIS actors and 'new' innovation agents (civil society, public sector actors, users, etc.) knit together in/influenced by dynamically developing networks and evolving institutional configurations at multiple scales
Production and application sides	Supply side (generation/production of innovation in the region)	Supply side and demand/application side (experimentation/diffusion/upscaling of innovation in the region)

Source: Own compilation.

institutional configurations, and (ii) include new actors, create new assets and networks, and engage in institutional change in order to tackle those challenges.

This definition partly overlaps with but also differs from similar concepts such as mission-oriented innovation systems (MIS) (Hekkert et al. 2020, 77), which are defined as 'the network of agents and set of institutions that contribute to the development and diffusion of innovative solutions with the aim to define, pursue and complete a societal mission'. MIS forms around a particular mission or challenge. A CoRIS, in contrast, is not necessarily confined to a particular challenge. It rather constitutes the wider regional (territorial) framework, reflecting the capacity of regions to address various and partly interrelated challenges. An example would be the environmental problem of climate change and the socio-economic problem of fighting unemployment in a peripheral or old industrial region. Activities geared towards battling climate change can stimulate the creation of jobs in new green economic fields but may also cause further job losses due to the closures of polluting industries. Similar relations might exist between fighting both health-related and labour market challenges (i.e. creating jobs in health-related services). For CoRIS policies to be effective, it is important to take such relationships among different challenges in a region into account.

At a more concrete and operational level, particular challenges (such as CO_2 reduction) might be addressed by one or more CoRIS initiatives (such as energy-efficient buildings, improvement of public transport or introduction of e-mobility). A particular region thus can address one or several challenges with different CoRIS initiatives in each. Like challenges, CoRIS initiatives are interrelated. Ideally, they should complement each other in order to fight a particular challenge (e.g. investment in e-mobility and in renewable energy), but they may also be unrelated (energy-efficient buildings and e-mobility), or there might also be cases of conflicts (e.g. over scarce resources).

Arguably, this does not imply that a CoRIS is well equipped to solve all the challenges a region is facing in the same way. CoRISs may well show a stronger capacity to tackle some problems or challenges better than others. Much depends on the innovation capacity of public and private actors, availability of assets – including natural resources and other assets such as industrial, human, infrastructural, material ones (Trippl et al. 2020) – historically grown networks and institutional configurations. These inherited place-based structures and RIS elements can provide both potentials and constraints to the initiation and upscaling of challenge-oriented innovation in regions (Hansen and Coenen 2015; Trippl et al. 2020).

CoRISs help to grasp to what extent and in which ways RISs are able to mobilize (broadly defined) innovative agents who play a significant part in the experimentation, development, application and upscaling of innovative solutions that are geared towards solving societal challenges at the regional level. Like traditional RISs, CoRISs build on a multi-actor approach, but they differ from the former by including not only firms and actors in the research and government domains. They open up to a more diverse set of actors beyond triple helix settings, including public sector organizations, NGOs, users, citizens, etc., who take part in experimenting with challenge-oriented innovations that help to address specific regional problems. In CoRISs, established actors (policy-makers, universities, etc.) may take on new roles, and 'new actors' may enter the stage, initiating and supporting challenge-oriented innovation activities. Their motivations for getting involved can be very different (Hekkert et al. 2020), ranging from expected economic gains (firms) to willingness to solve their own needs (users), civic engagement

and a normative stance regarding the challenge (NGOs). They may also reflect organizational roles like universities that educate and train students, intermediaries that facilitate networking, or banks that provide financial assets.

As outlined above (see Section 2), tackling specific regional challenges often demands a bundling and combination of various (technological and non-technological) innovations, and institutional and infrastructural changes. In CoRISs, public and private actors coordinate their challenge-oriented innovative activities to develop complementary technological, institutional and other innovative solutions. Like traditional RISs, CoRISs may either emerge and grow organically (that is, in a bottom-up way) or driven by policy actions (that is, in a top-down manner). Developing a CoRIS involves modifying broadly defined regional assets and place-based structures through what has been termed 'system-level agency', that is, agents who implement changes at the system level leading to a reconfiguration of the RIS (Isaksen and Jakobsen 2017). In this context, it deems important to consider not only change agency but also maintenance or reproductive agency, i.e. agency that is oriented towards securing the persistence of existing structures, thus countering pressures for change (Henderson 2020; Jolly, Grillitsch, and Hansen 2020). However, the latter form of agency may not only have a dark side by being a source of failure of challenge-oriented innovation. Reproductive agency could also be essential for consolidating change (Baekkelund 2021), underpinning the wider diffusion of challenge-oriented innovations in the region.

We also propose paying close attention to the dynamics of challenge-oriented innovation networks and initiatives in CoRISs. As noted above (Section 3), tackling specific problems in regions requires more than developing challenge-oriented innovations in regions or experimenting with and applying solutions imported from elsewhere. Their upscaling in the region is pivotal for wider change, calling for reproductive agency (see above). There are strong reasons to assume that driving forces and barriers, actor constellations, as well as network and institutional dynamics, differ in the course of their development, requiring an adaptation of CoRIS policies.

Finally, it is important to emphasize that the evolution of a CoRIS is not only driven by its 'internal' (that is, regional) dynamics but is often essentially shaped by non-local influences and its connections to the 'outside world'. CoRISs are inserted into national and supranational regulatory and policy frameworks and innovation dynamics often include actors and factors from local to global scales (Binz and Truffer 2017). Policy impulses from higher spatial scales, national and supranational institutional barriers, importation of innovations developed elsewhere (Tödtling, Trippl, and Frangenheim 2020) and trans-local learning networks (Loorbach et al. 2020) may thus affect how challenge-oriented innovations unfold in regions.

5. Mobility transitions in the region of Vorarlberg – the case of an emerging CoRIS?

In this section, we illustrate and further explore the features of CoRISs through the analysis of a concrete case. Which implications are resulting from adopting a challenge-oriented perspective? What are issues and deficiencies that must be taken into further consideration using the framework/ideas of CoRISs? Based on a literature review, we zoom in on the case of the Austrian region of Vorarlberg and its emerging CoRIS,

addressing climate change as one challenge, with the focus set on mobility and energy production. We have chosen this case because this region introduced a comprehensive initiative to tackle climate change by covering both the sectors of transport and energy, and including a broad range of actors in the public and private sectors.

5.1. Setting the scene: Vorarlberg and the transformation of mobility systems

Mobility is organized within a socio-technical system, which is defined as 'a configuration of products, processes, services and infrastructures, regulations, skills, preferences, expectations, and actors' (Schot 2016, 447). In order to transform the mobility sector, the implementation of a singular new technology is not enough. Rather, it is the combination and application of multiple forms of innovation that matters, ranging from technological to infrastructural, social and institutional innovations. Thus, the transformation of the mobility sector is reconfigurational (Hodson, Geels, and McMeekin 2017). Furthermore, mobility is energy-intensive and thus closely connected to the energy sector and energy innovations. Since transitions towards more sustainable regional mobility systems demand innovations in multiple realms, a diverse set of actors needs to be mobilized, including – among others – firms, public administrations, NGOs, politicians and residents.

The region of Vorarlberg is located in the most western part of Austria, bordering Germany, Switzerland and Liechtenstein. Hosting around 400,000 inhabitants, it is the smallest of all Austrian federal states (Statistik Austria 2020). The region spans over a territory of 2600 km² and shows a higher population density than the national average (Statistik Austria 2020). Historically, the region of Vorarlberg was characterized by a strong textile manufacturing sector. Until today, the industrial sector is the cornerstone of the region's economy. Mechanical and electronic engineering as well as metals industries play an important role (Amt der Vorarlberger Landesregierung 2020, 7). The region features an above-average economic performance in national as well as European comparison (Statistik Austria 2020).

Innovation activities in Vorarlberg are mainly driven by companies: Around 80% of the R&D expenditures are carried out by businesses, while public R&D expenditures are below the Austrian mean (Amt der Vorarlberger Landesregierung 2020). The development of the R&D sector and stimulation of company-driven innovation potentials are at the core of the innovation strategy of Vorarlberg (ÖROK 2016). In a recent strategy paper on science and research, innovation is seen as a means to strengthen economic competitiveness and ensure regional prosperity (Amt der Vorarlberger Landesregierung 2020). Accordingly, Vorarlberg's RIS policy appears to focus predominantly on economic growth and the framing of innovation as generated through the interaction of R&D organizations and companies.

However, there is also evidence that over the past few years the pursuit of other goals than economic competitiveness gained in importance in the region, reflecting a broader understanding of innovation and an increasing 'challenge-orientation' of actors and policies. However, the emerging CoRIS is representing not more than a 'niche', co-existing with the still dominating traditionally oriented RIS (see above).

Although the focus of this article is on the regional scale, one needs to take into account that the region and its mobility system are integrated into trans-regional

processes, cross-scale relationships (Haarstad 2016), and in a global institutional context. Institutional configurations are shaping mobility and energy provision systems to a high degree. They are set across multiple levels of governance. National and European mobility concepts and policy regimes in terms of infrastructure, e.g. train lines and stations, highways, energy supply, and regulations have a strong effect on regional mobility innovations and transitions (Hodson, Geels, and McMeekin 2017). The following subsections disentangle essential features of Vorarlberg's CoRIS, zooming in on challenge-oriented innovation activities and policies in the field of mobility.

5.2. The case of the e-mobility model region 'VLOTTE' in Vorarlberg

5.2.1. Context and rationales

Facing environmental problems due to climate change and air pollution, the region of Vorarlberg established Austria's first e-mobility model region VLOTTE in 2008. The main objective of this challenge-oriented initiative was to test the application of various forms of electric mobility innovations. Further, in 2009 the regional parliament of Vorarlberg set the strategic goal of achieving regional energy autonomy by 2050 (Amt der Vorarlberger Landesregierung 2015, 2020). Thus, VLOTTE was soon included in the region's ambitious goals in the energy field (Ryghaug et al. 2019). Consideration of the 'mobility-energy nexus' became apparent in VLOTTE's core objective, that is, to enhance low-emission and low-carbon mobility fed by regionally produced renewable energy. Thus, challenge-oriented and economic goals were aligned to each other, that is, reduction of emissions resulting from mobility and the expanded production and use of local renewable energies.

5.2.2. Multiple innovations at the application side

Vorarlberg does not host an automotive industry. Thus, the technologies and e-vehicles are imported from other countries. Consequently, a focus on innovations at the application side is at the core of VLOTTE (Tödtling, Trippl, and Frangenheim 2020). Therefore, experimentation with and local adaption of technologies generated elsewhere, social and institutional innovations (e.g. car leasing contracts with the local energy provider, development of a diverse charging network, conversion to electric vehicle fleets) are of central importance. This points to the significance of CoRIS' capabilities to foster multiple – and complementary – forms of innovation, and to forge their interplay, thus fashioning the reconfigurational dimension of socio-technical transformations. This is inextricably linked to the capacity of the CoRIS to mobilize a broad set of actors, to develop challenge-oriented networks, and to harness and reorient institutional endowments.

5.2.3. CoRIS: actors, networks, institutions

Due to the broad agenda in the initiation phase and the necessity to engage in manifold innovation activities (see above), the set of actors involved comprised a diverse mix of public and private service providers, policy actors, research organizations and users. Especially the public sector took a strong hold. A central role was played by the local utility and energy provider Illwerke vkw, of which the regional state of Vorarlberg holds 98% of the shares. Illwerke vkw was one of the main initiators of VLOTTE,

ensured the electricity supply, integrated a large rooftop photovoltaic system and built up an e-car park. It also installed a charging infrastructure and provided leasing contracts for electric cars. Being a locally established actor, it enjoys public trust, which was crucial to support the adoption of early e-vehicles, including non-matured technology (Martin 2018). It was thus an incumbent actor in the energy sector who played a leading role as a change agent at the system level in challenge-oriented innovation processes in the regional mobility system. Illwerke vkw made use of its established position to implement new technologies, to fashion cross-sectorial links and to mobilize actors in the region. Further, in the course of the development of the challenge-oriented initiative, VLOTTE became one of the business branches of the energy provider (see above). In consequence, economic as well as environmental objectives were pursued.

Besides Illwerke vkw, a large number of other actors and their agencies drove the evolution of VLOTTE. The local research organization Kairos (Wirkungsforschung und Entwicklung GmbH), an independent non-profit organization, was the first actor in Vorarlberg's challenge-oriented initiative who followed up with e-mobility. Kairos developed an e-mobility concept for the region and further collaborated intensively with Illwerke vkw in order to become Austria's first e-mobility region. Vorarlberg's successful application for financial support from the national Climate and Energy Fund can be seen as the outcome of collaborative links between these two key CoRIS actors, coalescing Kairos's concept with Illwerke vkw's capacity to implement it. Eventually, becoming part of the national e-mobility model region programme was a crucial moment for the further development of this challenge-oriented initiative in Vorarlberg.

Other actors involved were the public transport provider Vorarlberger Verkehrsverbund who integrated electrically powered buses into their fleet and the regional environmental association Umweltverband Vorarlberg as well as the Energy Institute Vorarlberg, which provided assistance for acquiring electric cars and advice for activities aiming at the aspired energy autonomy. The regional assurance company Vorarlberger Landesversicherung contributed by covering for the costly batteries (Martin 2018). In the private sector, a local carsharing provider converted its fleet to mostly electric cars, which raised the visibility and helped to break down barriers towards e-mobility for private users. As local car trading companies were not able to adapt and offer adequate consultation and services for electric cars and e-mobility, these tasks were filled by Illwerke vkw (Martin 2018). Altogether, a broad group of users, including public regional and municipal administrations, businesses as well as private persons, took part. Experience and feedback from these users were crucial in the maturing process as they helped to adapt and improve the technologies according to their needs. With the upscaling of the challenge-oriented initiative, the set of actors was further growing (e.g. more business owners and restaurants were enlisted to enable the supply of charging stations to their employees and customers) (Ryghaug et al. 2019).

Taking a closer look at the formation and evolution of networks in this initiative reveals a number of interesting insights. Many actors involved knew each other previously. Some of them even had organizational links, e.g. Illwerke vkw and the Energy Institute met up regularly (Martin 2018). The strong connection between Illwerke vkw and the regional government is considered a particularly relevant factor in the success of the VLOTTE project (Ryghaug et al. 2019). In other words: pre-existing links facilitated the formation of challenge-oriented innovation networks and alignment of

activities to funding opportunities. Regional policy actors engaged in reproductive agency by fostering the building of network structures and inducing learning processes by organizing networking meetings, bringing actors together to share information about their projects and measures. Users were integrated by solicitation of feedback and usage analysis (Martin 2018). It is also important to note that network characteristics changed over time. In the experimentation phase, when the terrain was mostly unknown, the cooperation among key actors needed more personal interaction and was time-intense compared to later stages, when the challenge-oriented initiative became increasingly consolidated and positions were clear and tasks divided.

The adoption process of e-mobility and regional socio-technical transformation were influenced in essential ways by regional institutional factors. Worth mentioning is the strong environmental consciousness in Vorarlberg, which is also reflected in the regional objective of energy autonomy and which clearly favoured the experimental implementation of new mobility forms. Due to the smallness of Vorarlberg and its peripheral location in Austria, other key factors were trust (see above) and a strong regional identity, fostering collaboration between diverse actors (Martin 2018). Furthermore, setting the goal of becoming energy-autonomous by 2050 offered fertile ground for the adoption of e-mobility fed by local energy production. It can indeed be seen as a guiding collective vision that helped to channel activities geared towards fostering the transformation of the mobility system. Institutional barriers to the adoption of e-mobility were building regulations, which complicated the implementation of charging infrastructure (Martin 2018).

Taking a closer look at the development of VLOTTE, two stages can be identified. In the initiation phase, the e-mobility model region received funding from the national Energy and Climate Fund to test the broad applicability of e-mobility in the region. In the upscaling phase, the challenge-oriented initiative was narrowed down. VLOTTE became a business branch of the local energy service provider Illwerke vkw with the core activity being the wider uptake of automotive electric mobility and the expansion of the charging infrastructure and renewable energy supply. This shift in orientation – from the application of different forms of e-mobility and intermodality towards an exclusive focus on electric cars – reveals how directionality may change during the life span of a challenge-oriented initiative.

5.2.4. CoRIS and its multi-scalar contexts

Place-specific CoRIS structures and dynamics have had – as shown above – a significant impact on the development of VLOTTE and thus on transforming Vorarlberg's mobility sector. Yet, the emergence and development of the challenge-oriented initiative under consideration here can only be properly understood by taking multi-scalar contexts into account and by paying close attention to non-local actors and translocal networks. Institutional conditions and policy actors at national and supranational levels shaped challenge-oriented innovation activities towards e-mobility in Vorarlberg to a high degree. EU guidelines aiming at the decarbonization of fuels created a beneficial context for the experimental implementation of e-mobility systems (BMVIT 2016). The national-level set incentives for innovation, encouraging regional transitions to low-emission mobility. It was the funding granted by the national Energy and Climate Fund that enabled the launch of VLOTTE as an e-mobility model region. Furthermore, extra-regional connections were built with other e-mobility model regions in Austria to enhance the exchange of experiences with strategy development and implementation and

to promote inter-regional learning processes. This does not only demonstrate that the 'non-local dimension' can impact heavily on challenge-oriented initiatives at the regional level. It also shows that the capacity of a CoRIS and its actors to navigate through various spatial scales to mobilize resources for initiating and consolidating transformation processes in the regional environment is vitally important.

5.3. Discussion

The climate oriented e-mobility project VLOTTE could be seen as a CoRIS initiative in an overall still conventionally oriented innovation policy setting that favours corporate innovation and economic competitiveness. Yet, the case of VLOTTE reveals a number of interesting insights into how CoRISs may address societal challenges at the regional level. The challenge-orientation of Vorarlberg's RIS manifests itself in the setting of well-aligned strategic goals and visions oriented towards sustainable transformation processes in the energy and mobility sector. This can be seen as main condition for the CoRIS initiative, which helped triggering wider innovation processes that include complementary technological, social and institutional innovations.

The case of VLOTTE also demonstrates how challenge-oriented actors mobilize regional and extra-regional resources and networks in order to boost CoRIS initiatives to transform the regional mobility system. VLOTTE was driven by innovative actors in the public sector and soon became populated by a large variety of actors who do not belong to traditional triple helix constellations. By successfully broadening the set of actors (inclusion of firms, users and other stakeholders) and by mobilizing policy support from the region and beyond, the challenge-oriented initiative gained wider acceptance. Vorarlberg significantly increased its number of e-vehicles per capita and became a leading e-mobility region. Regional and national level policy actors promoted the experimental process by providing a protected niche for the new technologies by means of financial and network support.

However, the case of VLOTTE also points to the fact that innovation dynamics in CoRISs could lead to solutions that diverge from the initial objectives. Starting with experiments oriented towards 'sustainable mobility systems' (that include both public and private transport and various modes of mobility), the transformation process became increasingly narrowed down, concentrating on electric cars only. This raises important questions about how visions in CoRISs – and in challenge-oriented initiatives – evolve and how to ensure that innovation trajectories stay aligned with societal goals. In the case of VLOTTE the strong focus on electric cars may be hindering a more sustainable transformation of the mobility sector, encompassing problems that are related to disposing of used batteries, the fact that electric cars still are an individual mode of transport that consumes a lot of valuable energy and needs a lot of space for driving and parking compared to public transport. This points to a potential dark side of challenge-oriented innovation and difficulties around the evaluation of success in a CoRIS.

6. Conclusions

The past years have seen a shift in the rationales for innovation policy. Addressing societal challenges such as climate change, degradation of ecosystems and other problems

that threaten human prosperity are increasingly ranking high on both research and policy agendas. This is reflected in a growing body of work on new approaches such as mission-oriented innovation policy, responsible research and innovation and transformative innovation policy. In stark contrast to traditional frameworks, these novel approaches place societal challenges and directionality of change at centre stage and propagate a broader understanding of innovation, inclusion of new innovative agents and an enriched role of policy.

In this article, we assert that RIS studies and policies have been slow in taking these advances into account. Much work in this field is still confined to analyse and provide support for technological and business innovation for economic competitiveness, thus building on a narrow understanding of innovation and featuring an uncritical view on its purpose. The article contents that RIS scholarship and policies need to grapple with the directionality of change, open up to a broader understanding of innovation (and its dark side) and pay more attention to the application of novel solutions to solve concrete challenges 'on the ground'.

Our call for rethinking RIS scholarship and policies is not to deny that many environmental and social challenges are global in nature. Yet, tackling these challenges also requires actions at lower levels such as the regional one. We propose the notion of CoRISs to grasp how multiple actors (firms, public actors, consumers, civil society organizations, universities and so on) coordinate their innovation activities to respond to (overlapping) pressing problems. CoRISs are (those parts of) RISs that show the capacity to mobilize existing actors, resources (assets), networks and institutional configurations, and to incorporate new actors, create new assets and networks, and change institutions to tackle environmental and social challenges.

One can draw a number of conclusions for the next generation of regional innovation policies. Overall, CoRIS policies move beyond the still-dominant RIS policy approach and its orientation on deficiencies of the existing innovation systems, such as gaps in the research and education infrastructure, lacking qualifications and skills, or finance and venture capital. As argued above, such a perspective is not sufficient for dealing with current and future societal challenges. A wider and more radical approach should take into account future needs and potentials to tackle societal challenges both from a regional and global perspective. This includes the involvement of new actors, an engagement with sustainability goals, and new ways of coordinating more open innovation processes (Morgan 2017). The stimulation of innovation should be complemented by 'the purposive termination of existing institutions, (infra)structures, technologies, products and practices' (Heyen, Hermwille, and Wehnert 2017, 326) that tend to inhibit or slow down the uptake of innovation. Consequently, RIS studies and policies need to pay more attention to destabilization interventions (Kivimaa and Kern 2016).

However, developing a RIS in the direction of a CoRIS is not a straightforward and easy process. Several tasks and steps seem to be vital (Foray 2018; McCann and Soete 2020), including the need to prioritize goals and interventions in order to take effective action. Broad participation of social groups, stakeholders, regional actors and policy-makers in shared vision building processes is deemed important in this context. It also involves dealing with potential conflicts of interest between actors involved, calling for balancing and coordination activities based on strong capacities of communication and leadership in the policy system. For setting up and developing a CoRIS initiative necessary

financial, human and other resources and assets from the region and beyond have to be mobilized. Implementing and upscaling of CoRIS initiatives requires commitment, investment and innovation activities in both the public and private sectors. This calls for the coordination of involved actors both within and between CoRIS initiatives.

There are arguably many issues and questions that deserve due attention in future research on CoRISs and challenge-oriented regional innovation policies. Thorough analyses are required to better understand in which ways regions differ in their capacities to reorient their RISs in order to bring it in closer touch with grand societal challenges and why they respond differently to the same global challenges. To this end, exploring the relative importance of the interplay between a broad set of place-based structures and assets and investigating the agency of key RIS actors, evolving networks and institutional dynamics should rank high on research agendas. Furthermore, addressing the question of how policy actions and institutional arrangements at higher spatial scales, non-local public and private actors, trans-local networks and mobilization of extra-regional assets influence the evolution of CoRISs and shape regional challenge-oriented policies and initiatives appears important. Finally, analyses are required to assess under what conditions CoRISs could also help the region to gain competitiveness (pointing to the potential to reconcile broader societal goals with narrower economic ones) or growth independence (Tschumi et al. 2020).

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